Texas Highway in Spring

The HUMBLE WAY

MAY-JUNE, 1946

The HUMBLE WAY

Vol. II MAY-JUNE No. 1

FACTS BEHIND THE FIGURES

THE annual report issued by Humble, as is the general practice for all corporations, includes financial statements expressed in the accepted accounting terms. Many people find it difficult to understand the technical language of accounting, which is illustrated by terms such as fixed assets, working capital, amortization, and surplus. The average reader of such a report is as much at a loss as the accountant would be if he tried to interpret the terminology used by specialists in petroleum production and refining. As an experiment, this article endeavors to translate the financial statements into simple terms in order to indicate the facts behind the figures.

The financial report attempts to show what has happened during a given period of time and the status of the business as of a certain date. The first of these reports is termed an income statement and shows what happened during the year. The financial results of Humble's operations for 1945 are shown graphically on the following page.

The term "gross operating income" used in the financial report represents all income received for everything the Company sold and did—the production and sale of oil; transportation, refining, and distribution of oil and products; management of government plants; and related operations.

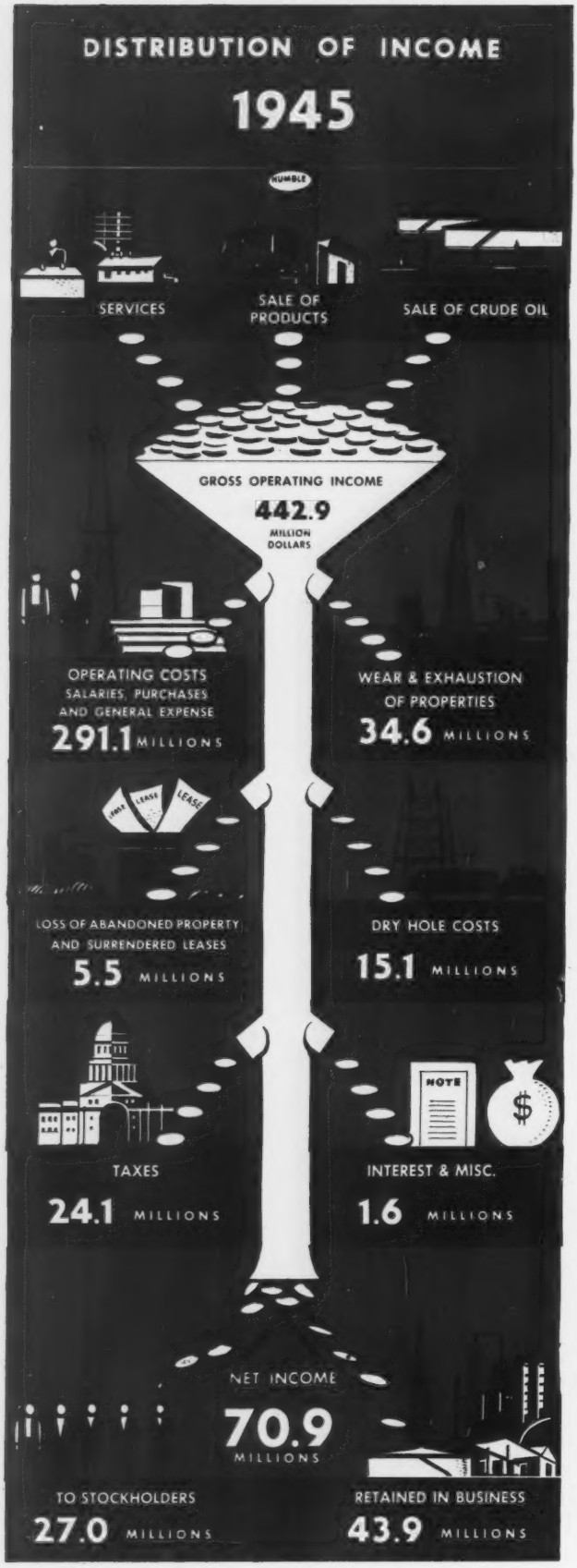
The costs and expenses of producing the income are divided into several classes. The principal expense is termed "Operating Costs and General Expenses" and represents what the Company spent for materials and supplies used, for wages and salaries, for services rendered to it, and for countless other bills. The expression "Depreciation, depletion, and amortization" is used by the accountant to refer to that portion of the cost of properties and permanent facilities considered to have been used up during the year due to exhaustion of properties and wear of equipment. The amount of such wear and exhaustion during the year 1945 was estimated to be $34,600,000, equivalent to about five per cent of the original cost and 10 per cent of the remaining cost of properties and facilities. The allowance for this item of expense is necessarily an estimate based on the anticipated life of the property. When properties are lost or abandoned sooner than was contemplated, the remaining cost is shown as a loss on abandoned properties.

The cost of dry holes and the losses on leases surrendered illustrate the risks involved in the oil business. Humble spent more than $15,000,000 in 1945 on wells that failed to produce oil or gas. Those dry holes cost an average of about $100,000 each. In addition, leases surrendered during the year had cost $3,600,000. Such a loss is typical, for in exploration for oil, it is often necessary to lease land which later developments indicate is not likely to produce oil. The bonus paid for the privilege of leasing the land is considered a capital investment until the property is surrendered, at which time it is charged to expense.

The Company also paid in 1945 $2,000,000 interest on about $43,000,000 of borrowed money. This item also includes the premium paid for retiring some of the debt before it was due, which was done in order to take advantage of lower interest rates available by refinancing the debt. Taxes amounted to $24,100,000 in 1945, including federal income and excess profits taxes, state and local property taxes, production taxes, and many other taxes, but not the gasoline taxes collected from consumers for the government.

The total of all the expenses incident to producing the Company's income is deducted from the amount received during the year to determine the net income left. Net income is a remainder after all expenses and taxes are paid and proper allowance is made for the wear and exhaustion of properties. It represents the return to the Company and its stockholders for all the work done during the year. The net

MAKING READY to lay a section of the Baytown-to-Dallas products line across a small Texas creek.



income in 1945 was only about 0.4 cent a gallon for each gallon that Humble either produced, refined, or transported.

Dividends paid represent the amount distributed to stockholders for letting the Company use their facilities. The payment of $1.50 per share was less than 3.5 per cent on the average market value of the stock for the year 1945. The money left after paying all expenses and dividends was retained in the business, principally to be invested in more wells, pipe lines, refinery units, and similar capital assets.

The income statement showing the results of operations during the year is supplemented by another report on the financial condition of the Company as of a certain date. This financial picture is shown in a statement which the accountant calls the "balance sheet." It is a classified listing of what the Company owns and of what it owes with the difference between the two figures representing the stockholders' interest in the business, which is termed "capital stock and surplus." If the balance sheet were translated into non-financial language, Humble's situation would appear as shown graphically on page 3.

The cash item of $49,200,000 represents the same thing as an individual's bank balance. It is required to carry on transactions from day to day. It amounts to only 12 per cent as much as the revenue handled by the Company in the year 1945. On the basis of this same relation, a person with an income of $3,000 a year would have a bank balance of $360.

The Company held $48,300,000 of government securities at the end of the year. A large part of these securities was purchased to offset the money due for federal taxes in the amount of about $29,600,000. There is no withholding tax for corporations, but Humble elected a few years ago to follow what amounts to a withholding tax plan by the purchase of U. S. securities to meet future tax payments.

Money due from customers and money owed by the Company to others reflect the normal delay in settling for the innumerable transactions that occur each month. For example, the Company may sell some oil and gasoline in one month which is not paid for until the next month. Similarly, the Company has purchased large quantities of oil during the month but is not able to complete the accounting work and issue the checks for this oil until later.

The inventories owned by the Company are divided into two classes. One class represents the crude oil, petroleum products, and other merchandise that the Company sells. The other class of inventories consists of the materials and supplies, such as steel pipe, that the Company must have on hand for its own use. These inventories are carried at what they cost.

The largest part of what the Humble Company owns (its assets) is represented by such properties as mineral leases, producing wells, refineries, pipe lines, service stations, and similar facilities. Properties of this nature are referred to in accounting terminology as "fixed assets" because they represent items owned that are relatively permanent. In reading this part of the "balance sheet," it should be borne in mind that properties which the accountant calls "fixed assets" are shown at their cost to the Company less the amount of these costs which has already been charged to expense as wear and exhaustion. This practice of stating properties at cost, even

though they may actually be worth more than that, is followed generally in accounting. The "fixed" properties which Humble owned at the end of 1945 cost originally $664,300,000. Of this original cost, the Company had charged $280,100,000 to expense over a period of years, leaving a remaining cost of $384,200,000.

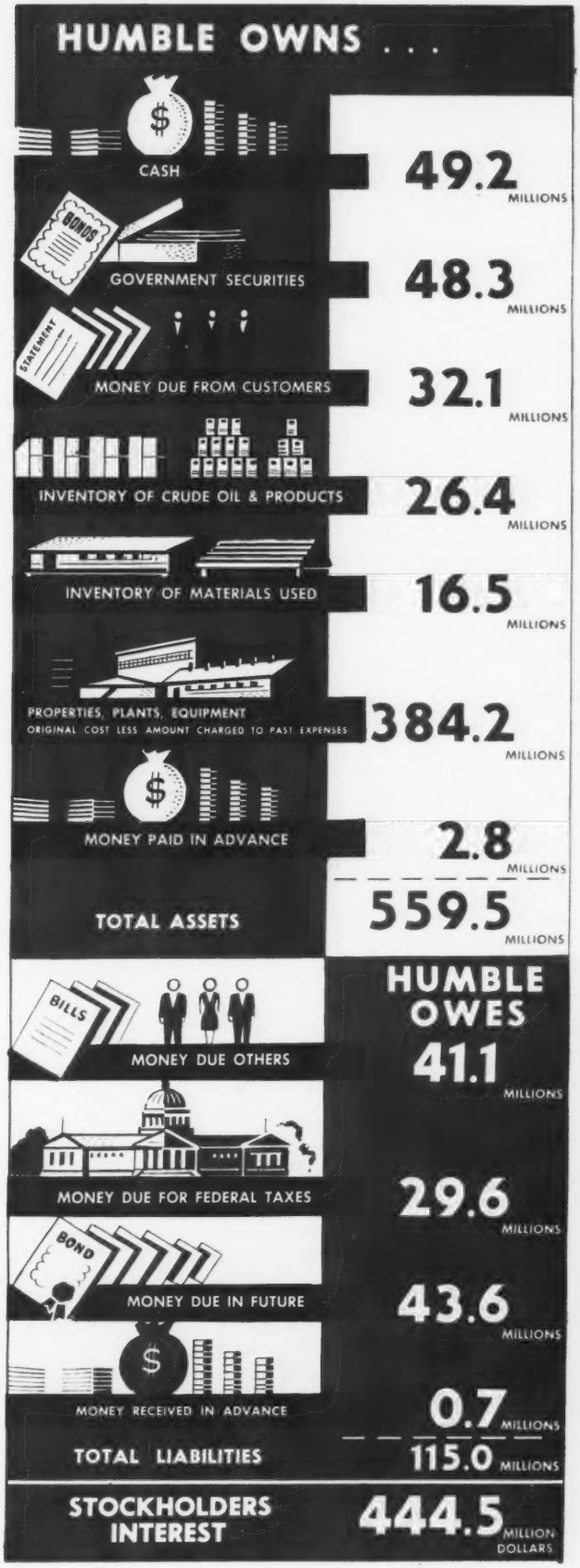
The Company sometimes pays in advance for things to be delivered later or makes small investments that are incidental to the normal operation of its business. Items of this type are shown by the accountant as a part of what Humble owns under the titles of "investments and advances" and "prepaid and deferred charges." A similar item, known to the accountant as "deferred credits," represents the amount that Humble's customers have paid in advance for goods and services to be delivered in the future.

The amount called "long-term indebtedness" on the balance sheet represents money payable in future years and not immediately. It is money which has been borrowed at specified rates of interest and is to be repaid according to schedule agreed upon with the lenders.

The difference between what the Company owns and owes represents what the stockholders invested in the business originally plus earnings of the Company that have been left in the business by stockholders in order to permit the Company to expand its activities. In the case of the Humble Company, the stockholders' interest at the end of 1945 was $444,500,000, according to the financial books, which do not include any allowance for appreciation in value due to discovery of oil and gas on properties owned by the Company. The amount shown by the books as the stockholders' interest is referred to by the accountant as "Capital Stock and Surplus."

The terms "surplus" may leave the wrong impression with many individuals that it represents idle cash that the Company has accumulated. Such an impression is completely erroneous, for most of the funds left in the business are for the purpose of prompt investment in properties and facilities. In Humble's case, earnings retained have been used to buy properties, drill wells, build refinery equipment, construct pipe lines, and make other permanent investments. While "Capital Stock" was carried on the books at the end of 1945 as $175,000,000, the remaining cost of the properties owned by the Company was $384,000,000. This comparison indicates that most of the so-called "surplus" has been invested in permanent facilities, while the remainder has been used to purchase the inventories and to provide the cash needed to carry on the business.

It is interesting to note that the net investment in Humble's properties, plant, and equipment of $384,000,000 represents nearly $25,000 per employee. In other words, it takes at least $25,000 of "fixed assets" to provide a job for the average worker in the Humble Company. The total funds required on the average, including inventories and cash needed to conduct the business to provide a job for one employee amount to $30,000. Consideration of how hard it would be and how long it would take for an individual to save $30,000 serves to indicate the advantages of a form of organization in which stockholder and employees pool their money and work, respectively, to the benefit of both parties.



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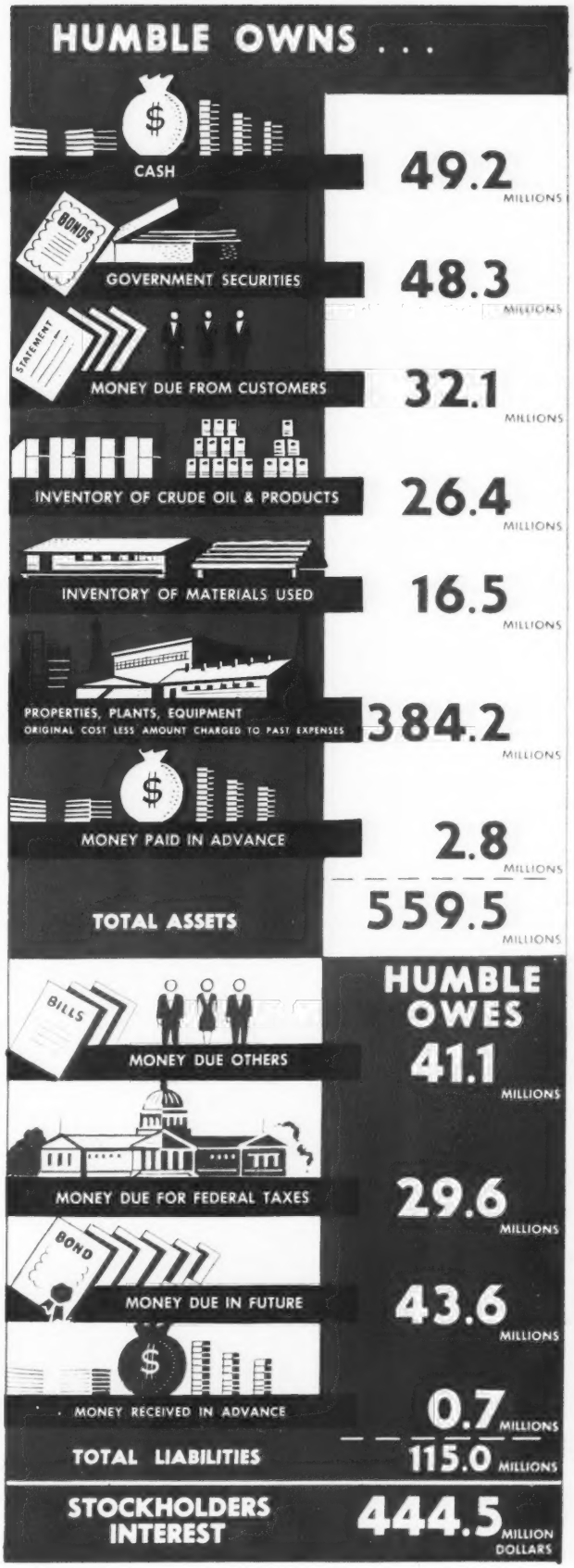


The Road, *the* Auto *and* OIL

By CHARLES E. SIMONS
Executive Vice President, *Texas Good Roads Association*

Texas has made great strides in highway construction since days of Byrd Lockhart, pioneer road and transportation enthusiast.

IMPROVED ROADS, plus the gasoline propelled motor vehicle, plus sound, enterprising, and economical development of our oil resources have combined to cause a revolution in the history of the world—a revolution which has brought to the people of the United States the greatest freedom of personal movement and has contributed materially toward bringing about the highest standard of living any nation has yet achieved.

Time was, and not so long ago, in Texas that man was bound to a radius of the few miles he could cover on his horse. Later, his sphere of travel was extended by the railroad—if he was fortunate enough to live on or near a rail line. Most of the middle generation easily can remember when going to Grandma's for Christmas was quite an adventure if it involved a trip of more than 50 miles, and when persons who traveled across the country by train were regarded as adventurers.

The combination of a good road, a good automobile and good motor fuels has changed the entire picture of American life in less than a quarter of a century. When one stops to ponder them, the changes, both social and economic, are startling.

In the highway-automobile-oil era it's get in your automobile, step on the starter and go... Go any place you want at any time you wish... Make your own schedule, changing it when and as your fancy or your business affairs might dictate... Include a couple of side trips if they look attractive... Make the return trip at your own convenience.

When you have an entire nation operating on this basis, things are certain to move a little more smoothly on the Road to Progress.

Texas has made much progress in road building since the time of Byrd Lockhart, one of the state's earliest road enthusiasts. Lockhart had the right idea about the value of roads in the transportation picture and about the value of transportation. He had a vision back in the 1820's "to build roads to facilitate travel and to stimulate the internal commerce of the country." He preached this road gospel as he went about the difficult task of constructing a wagon road from San Felipe de Austin to Gonzales and San Antonio and from Gonzales to Matagorda Bay. Texas then was a wilderness awaiting the march of progress.

One hundred years later Lockhart's dream, magnified many times, had come true. Travel *had* been facilitated. He would be amazed to observe the 1,750,000 vehicles plying busily over the State's highways and the stimulation which this travel is giving to the internal commerce of the country.

To Lockhart, a method of transportation was the most important thing needed in the development of a virgin empire. In his day, the transportation needs of the people, though highly important, were relatively simple, yet this man's viewpoint stands today as the foundation on which heavy expenditures for highway construction are justified without challenge.

The pioneer's main need for a passable road was for market outlets for his surplus products. To the citizen living amid the ultra-modern achievements of today's post-war atomic age a method of easy, quick ground transportation is of even more vital importance.

Living in the present era, crowded together in large cities—or because of lack of housing facilities, forced to live 30 commuting miles away—modern man is more dependent than ever on his lines of transportation for his food, clothing, and shelter. If the highways leading to any of our great commercial centers were blocked for more than 72 hours, the dread specter of hunger would cast its shadow on these cities, and surplus products of the farms and ranches would pile up unused. Industry and commerce would be stopped and our national economy would wither like a tree whose root system had been destroyed.

The average citizen's chief form of transportation is by highways, and so it is there his chief interest lies. His interest is such that he, and others like him, has contributed millions of dollars for construction and maintenance of a system of highways. It is his system, paid for by him and his fellows and designed for his chief benefit, whether it be for hauling his potatoes, cattle, or cotton to market or for taking his children to school.

Since the days of Byrd Lockhart, Texas has come a long way in the highway field. Its system of highway transportation has grown from the few miles established when Texas was wilderness to a road network which, including state and county highways, approximates 193,000 miles and serves one and three-quarter million vehicles and nearly seven million people. The system of state highways now includes 24,665 miles of main roads. These roads carry 71 per cent of all rural traffic—that traffic outside the corporate limits of cities; these roads are maintained by the state. In addition, there are on the state highway system as "conditional designations" more than 2,500 miles of roads that are not maintained by the state. These are roads on which no construction has been undertaken but on which it must be undertaken at some future date if Texas is to have a well-rounded and efficient state highway system.

HIGHWAYS, CARS, AND OIL SERVE AMERICA NIGHT AND DAY IN COMMERCE AND INDUSTRY, IN EDUCATION AND RECREATION

The Texas State Highway Department was not even a dream when the automobile was invented, to bring with it a multitude of new problems in the field of road design and use. All road-building up to that time had been entrusted to the counties and the farmer who had to make a buggy trail from his residence to the main mud track. The county, itself, had entire jurisdiction over laying out and constructing all roads. This made for small networks of roads—all leading to the various county seats but with no major connecting links between.

With the advent of the automobile and development of intercounty and interstate travel, the picture called for some statewide organization to unify and, in some measure, to standardize the non-local roads. Without such an organization confusion and lack of coordination were certain to prevail among the units and levels of government that had administrative authority over roads, streets, and highways. Commissioners' precincts in Texas counties found a demand for the improvement of roads which did not fit into a logical pattern for the county as a whole.

So it was a consequence born of necessity that when Congress passed the Federal Aid Road Act in 1916, a new influence made its appearance in the field of highway legislation. To comply with the Federal Aid Road Act, the Texas Legislature in 1917 enacted a statute creating the State Highway Department and a new era began in Texas highway history. At that time, 9,100 miles of Texas roads were designated as the original state highway system. Only about 1,600 miles of roads scattered through the state were surfaced, most of these being only gravel.

During the formative period of the State Highway Department, the Highway Commissioners depended upon the U. S. Bureau of Public Roads for the influence that insured uniformity in designs and practices through the use of federal aid regulations. The first federal aid, in amounts of money granted, was not impressive but it served as an inducement to get the desired results. Few other instances of state and federal cooperation have produced such remarkable results in obtaining uniformity and efficiency.

In the next decade the Texas Highway Department was charged with the stupendous job of classifying and attempting to designate those sections of Texas roads which best could be knitted into a unified system of transportation arteries for its ever-increasing industrial and farm products. Upon the State Highway Department fell more and more responsibility for turning these small units of county road systems into a part of the whole. In 1932, the State assumed the payment of those portions of county and district bonds determined to have been expended in construction of highways that were taken over by the State when Texas established its system of designated highways. To pay off the local obligations that had been incurred on behalf of the State, the legisla-

YESTERDAY'S ROADS were adequate for yesterday's slow cars, but in this age of speed, roads are built for safety, beauty, and long life.

ture diverted one cent per gallon—one fourth—of the gasoline tax to a bond fund. This tax had originally been enacted in the early 20's as a means of gaining revenue specifically for the construction and maintenance of the roads to be used by the man who paid the tax.

In establishing the state highway system, an intensive study was made of the roads which should be included in the original mileage. Similarly, close scrutiny has been given to each request for designation of a road as a state highway to insure that the really important roads were included and improved from state tax funds. That a fairly competent job was done in this respect is shown by figures compiled by the Federal-State Highway Planning Survey. The 26,000 miles of state roads carry approximately 90 per cent of the total traffic, rural and urban, leaving to the 170,000 miles of county roads only 10 per cent of the traffic.

Today, through combined research of State and Federal road agencies, more and better roads can be built more economically. Through Federal Aid the states share on a uniform basis in the building of a national highway system. Contracts are usually awarded by the State Highway Department. This program, in effect since 1916, is authorized by Congress every two years in advance. Since the beginning of the program, the states have received a share proportioned on a formula based on population, area, and road mileage.

From the meager 1,600 miles of scattered surfaced roads in 1917 the Texas highway system has grown into a gigantic network of connected transportation arteries over which flow millions of dollars daily in commercial products and goods. As of September, 1945, the system of designated State highways (exclusive of farm-to-market roads) totalled 26,864 miles. That's a lot of mileage but it's still not enough.

Texas is a big state and its highways carry a heavy load. They not only carry Farmer Jones' chickens and eggs, cattle and fruit to market, or Manufacturer Smith's magnesium and plastics to the consumer; they carry Farmer Jones' son to work in the city, his younger daughter to school; they carry Manufacturer Smith to his outlying plants. These highways take the farmer's family and the manufacturer's family to the shore or the mountains during their summer vacation; they connect the places of historical interest so that both families can get a look at the scenes where their state's history was made.

These highways also bring into Texas what is now classed as one of its largest businesses—the tourist trade. The size of the tourist business is hard to estimate. But in the last pre-war year, Texas played host to more than 8,000,000 tourists. Now that the war is over and rationing a thing of the past, there will be an even greater influx of automobile travelers in the next few years. Most of these tourists will enter the state on the eastern boundary and travel across U. S. Highways 80 and 90, spending money as they go. Or maybe they will enter on the northern edge and follow Highway 81 south to Old Mexico. Wherever they enter—whether they stop over or pass on through—they'll ring Texas cash registers all along the highway. Texas will need adequate roadways to take care of the flow of visitors headed for its boundaries.

The constant pounding of military transports and heavy war loads on existing pavements and the inadequate maintenance brought on by wartime necessity has put much of Texas' highway system in critical condition. In spite of severe shortages in manpower and revenues, however, the State Highway Department has much to show during the war years on the progress side of the ledger. In September, 1940, the state system totalled 26,804 miles of which 8,727 were unpaved. Of this unpaved mileage, 4,357 miles were maintained by the State and the remainder were "conditional designations." Out of the September, 1945, figure of 26,864 miles, 2,557 miles were unpaved and of this unpaved mileage the State was maintaining 1,398 miles. Thus, during the war years the unpaved state highway mileage was reduced from 8,727 miles to 2,557 miles. Although the state highway system

ENGINEERS HOPE TO SPEED UP CITY TRAFFIC WITH GREAT EXPRES WAYS

(primarily roads) was held to the same approximate mileage, the State Highway Commission designated 7,205 miles of farm-to-market roads, bringing the state's total road obligations to 34,069 miles.

In the programs of work for the postwar period which have been approved, provision has been made for 1,181 miles of the 2,557 unpaved "state" miles, which leaves a total of 1,376 miles of this category of roads for which no provision has been made. If the State is able to carry out the present programs of work and no more mileage is added or funds appropriated, Texas will end the three-year postwar period with a total system of 34,069 miles, of which all but 1,376 miles will be paved. Of this unpaved mileage, the State will be maintaining 842 miles.

During the first postwar year the Highway Commission's program involves the construction of 2,162 miles of "secondary roads" and 821 miles of "primary highways" at a total estimated cost of $53,000,000. This money will go for paving, improvements, construction of four-lane sections, by-passes, clover leaf junctions, and for features to be incorporated as extra safety measures on the recommendations of highway engineers. These features are the results of extensive research concerning modern erosion control, better illumination of signs, safety landscaping, methods of traffic separations and preservation of pavement surfaces.

It is the motor user tax revenue that really builds the roads, and the Texas motorist pays plenty on the oil and gasoline he consumes to travel the highways. Every time he puts a dollar's worth of gasoline in his car, he hands out 20 cents in taxes for better roads. That's a big percentage, but without it he wouldn't have the better roads and it would cost him more to operate over bad ones. The tax itself is an equitable one in that is was originally meant that the highway user should pay for the improved highways.

All of the highway tax dollar, however, does not go back to the highway as originally intended. The state gasoline tax nets Texas between 40 and 50 million dollars per year. One-fourth of that amount goes to the available school fund; another fourth goes to the county and district road bond

TODAY'S PLANS call for the construction of four-lane sections, by-passes, traffic circles, and other carefully engineered improvements.

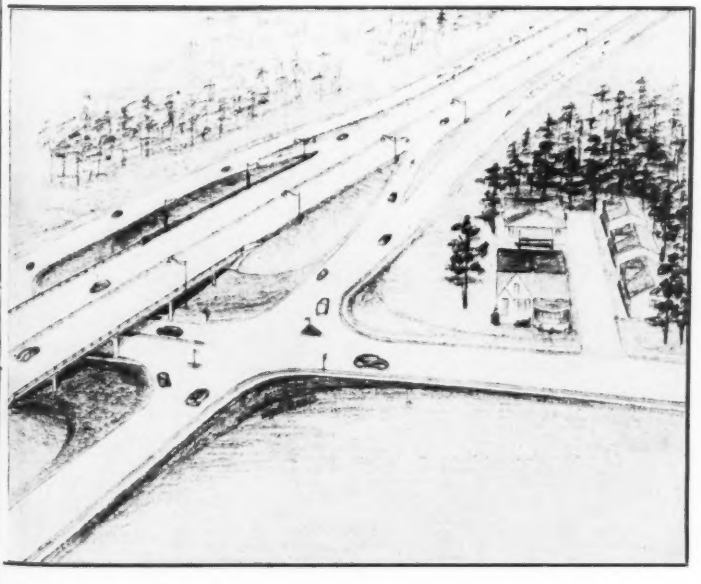
assumption and lateral roads funds for the benefit of the counties. The highway construction fund gets barely half. Even that amount, between 20 and 25 million dollars per year, may seem a large sum. However, consideration of the cost of highway construction makes it small, indeed. For instance, conservative figures show that a proposed farm-to-market road program will cost between $7,500 and $10,000 per *mile* just to get an all-weather road. A paved state highway will naturally greatly exceed that cost. Based on present income and present cost of construction, it will take at least another quarter of a century to bring the highway system up to the needs of today; provided there is not additional diversion or dispersion of gasoline taxes and other motor vehicle revenues.

It is a matter of acute financial interest to every Texan who gets behind the wheel of an automobile to see that no more of his gasoline tax dollar is diverted. In the next few postwar years the average American will spend his vacation on the road. With today's better oil products and better fuel for tomorrow's better automobiles, the tourist will take his travel where he will get the most for his money. Texas has much to offer, but her highways will have to be adequate.

As travel increases and more taxes are paid into the highway coffers, the means of building the better roads will be available, if no more attempts are made to divert or disperse the tax revenues which the Texas motorist gladly digs from his pockets. The oil industry, providing the source of power; the motor industry, providing the vehicles; and the people, themselves, providing the roads have formed a combination which has lifted Texas out of the mud. Without one the others could hardly survive. Highways, motor vehicles and petroleum . . . hand in hand, they serve the public, night and day, in commerce and industry, in education, in recreation.

As they grow, so grows Texas.

WAYS LIKE THIS ONE SCHEDULED FOR CONSTRUCTION IN HOUSTON



TREES GROW RIGHT UP TO THIS SALT WATER DISPOSAL WELL, AND CATTLE GRAZE ON GRASS GROWING NEARBY

Back to the SAND

Cooperative salt water injection arrests alarming reservoir pressure loss in great East Texas oil field

FROM THE ROAD, it looked like an oil well. Certainly there was nothing about the derrick, from this distance, to set it apart from the forest of steel growing around, and out of, Kilgore. But, closer up, one observed certain departures from equipment standard for most oil wells. Those strange vessels to the right, for example; two orderly rows of four each; squat, almost round, glistening in their new coat of aluminum paint. And that sturdy wooden tank near the well—could it be an oil storage tank?

No. No oil well, this. To disperse all doubt, a sign about ten feet up the derrick proclaims in bold block letters: "East Texas Salt Water Disposal Company." The steel vessels are filters; the wooden one, a surge tank. At this well the flow is *in*, not *out;* salt water, 10,000 barrels a day of it, is being pumped down through the tubing to the Woodbine sand more than 3,800 feet below. This is one link in a 33-well disposal chain serving the East Texas oil field.

But why such an elaborate system just to pump salt water back into the earth? Surely, if the stuff must be disposed of, some simpler and less expensive means could be found. All this, of course, is by way of second-guessing; there were good and definite reasons for installing these systems. For a better understanding of the salt water problem and its solution, one must go back to the root of the trouble.

More often than not, oil travels in bad company on its pool-to-surface trip through the producing string. Salt water, sometimes in discouraging quantities, hitchhikes its way to the surface along with the crude. Indeed, it is not uncommon for a water-drive field to produce more water than oil. A case in point is the fabulous East Texas oil field; here hydrostatic pressure, rather than gas, provides most of the power to force oil to the surface.

The field was 12 years old before it came of age from a

salt water disposal standpoint. A review of events leading to adoption of present disposal systems in East Texas is evidence of the oil industry's ability to meet and solve its own problems as well as its willingness to observe the rights of others.

Early producers in East Texas—and elsewhere, for that matter—refused to be bothered with salt water. Annoyed, but not alarmed, they disposed of the troublesome stuff at the surface with as little effort as possible. Sometimes, taking the attitude of a polite host toward an unbidden guest, they simply ignored it.

It was inevitable that a day of reckoning should come. No one had foreseen the extent and productivity of the field; it became one of the largest reservoirs of crude petroleum in the world, if not *the* largest.

Production went on apace; oil wells sprang up in back yards; millionaires were made over the weekend—and salt water, which had been just a nuisance, became a menace. There was trouble in every barrel of it. Surface disposal was contaminating and polluting present and potential farming lands; fish and vegetation were killed in surface waters; drinking water supplies were threatened; and increased withdrawals of both oil and water reduced the reservoir pressure at an alarming rate. From its original 1,620 pounds per square inch in 1930, the reservoir pressure had dropped by 1939 to 1106 pounds per square inch, and it was falling steadily. The way things were going, field pressure would be exhausted long before its allotted time.

Most students of water-drive fields could read the handwriting on the wall as early as 1935. In that year East Texas was producing only 15,000 barrels of salt water a day, but it was becoming painfully apparent that, from that time forward, the volume would increase in a ratio more algebraic than arithmetic.

A flurry of experimental activity began. They tried to evaporate the water; they stored it in surface pits and allowed it to percolate down into shallow sands; they released it during time of floods or heavy rains. All these efforts were foredoomed to failure; the volume was too great. At last, only two alternatives remained: construction of a pipe line or lines to the Gulf of Mexico, or injection into subsurface formations. The high porosity and permeability of the Woodbine sand below the oil interface made the latter course more attractive. A core of Woodbine sand looks very much like any other sandstone, but properly treated water flows into and through it with amazing ease.

So, in 1936, a group of East Texas operators experimented with returning salt water to the Woodbine formation through a specially drilled well west of the productive limits of the field, since it was from this structurally lower section that most of the water was being produced. The technique of returning salt water to the reservoir was carefully studied by a corps of chemists and engineers. As a result of this experiment, some of the larger oil companies decided to build and operate their own disposal systems.

In 1938, salt water production in East Texas reached 100,000 barrels per day; by 1939 that figure had been doubled; and by 1941 it had been redoubled to more than 400,000 barrels per day. Something had to be done—and soon! The volume of water had grown like Jack's beanstalk; reservoir pressure had fallen nearly 570 pounds per square inch under larger withdrawals of both oil and water.

The Texas Railroad Commission offered to help: it provided that operators might transfer the oil allowable from a well producing over 100 barrels of salt water per day to another well on the same lease. A little later, the Commission went even further; it encouraged operators to inject their salt water into subsurface formations by allowing them to produce one extra barrel of oil for every 50 barrels of salt water disposed of in this manner.

Meanwhile, the oil industry was busy with the problem, too. In July, 1941, a proposal was made to the Railroad Commission to establish a cooperative disposal system. This led to conferences among East Texas operators, large and small, out of which came the formation in 1942 of the East Texas Salt Water Disposal Company. Stock in this $2,000,000 Texas corporation, which has since assumed the status of a public utility, is owned by 251 oil companies—17 large operators and 234 small.

The Salt Water Company injected its first barrel of salt water on October 1, 1942. From that time through 1945 the company has grown to an organization of 175 employees, over 200 miles of gathering lines, 39 collection centers, and 33 disposal wells serving 2,776 oil wells producing water on 480 leases.

DESOLATE SCENES of salt water damage are still to be found in the East Texas field, but systematic disposal is reducing them rapidly.

Up to January 1, 1946, the company had injected 208,718,018 barrels of salt water back into the Woodbine sand, an average of 167,242 barrels per day. Last year (1945) they put back 88,267,231 barrels. August was the peak month, with a daily average return of 253,540 barrels; December 7—Pearl Harbor Day—the peak day, with 277,016 barrels. The David Frame Disposal Well, named for a director of Humble Oil & Refining Company, was the top performer for the year with 4,711,580 barrels, or 13,452 barrels per day to its credit.

About 77 per cent of total water produced daily in 1945—376,517 of 489,748 barrels—was returned to the sand. The Salt Water Company injected 64.23 per cent of these

EAST TEXAS Salt Water Disposal Company employee reverses polarity of electrodes generating chlorine to kill bacteria in treating pit water.

376,517 barrels; oil companies operating their own disposal wells accounted for the remaining 35.77 per cent. This year, a much larger percentage of total water produced is being returned; in March, 89.64 per cent was injected through all disposal wells. At last report, the field was producing about 455,000 barrels of water a day as compared with about 320,448 barrels of oil.

Considerable care and engineering effort went into the building of its system and, from the beginning, the East Texas Salt Water Disposal Company has been eminently successful. Help and advice were obtained in the early days from engineers and other personnel loaned to the company by operators in the field, among them Humble Oil & Refining Company. Here's how the system works:

Gathering lines made of materials to withstand the corrosion of salt water bring water from producing areas to collection centers. A thin film of oil which usually accompanies the water is skimmed off, some preliminary chemical treatment is given, and the water is sent on to a central treating and filtering plant. After filters have removed the last trace of solids, water is pumped or allowed to gravitate into the disposal well. Each step will be explained in detail.

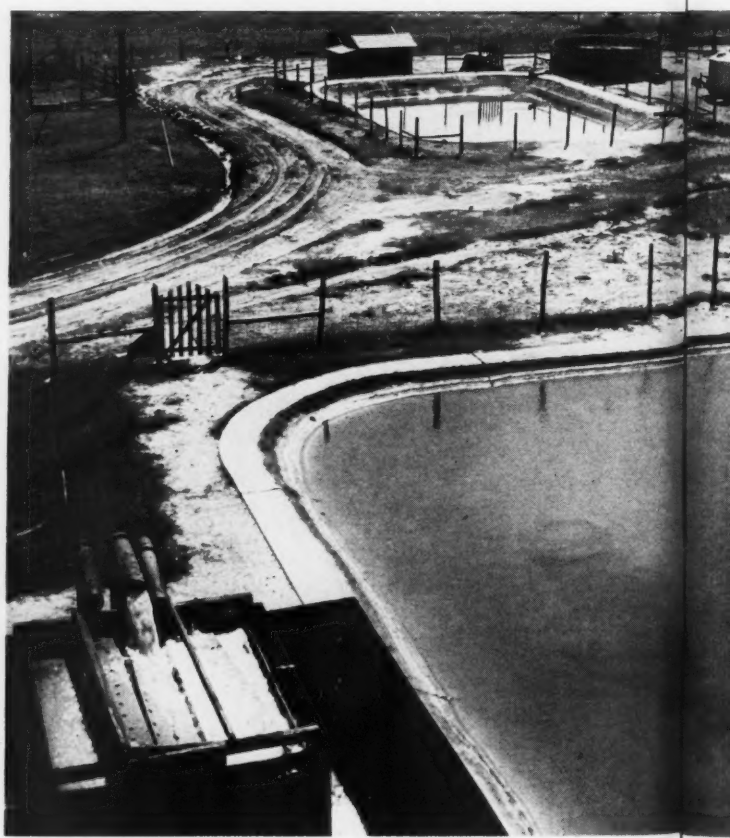
Wherever possible, collection centers are located at the lowest point in a general producing area. To these centers, through asbestos-cement pipes laid beneath pine-laden slopes, come thousands of barrels of water daily, flowing into the oil-skimming pit at a temperature of about 100 degrees Fahrenheit. Slotted pipes are installed just below the surface of the water, and these pipes may be raised or lowered to just the right level to skim off the film of surface oil, which may be sent to a burning pit or given to the County for topping roads.

Preliminary aeration follows skimming; this may be given at the collection center simply by passing a shallow depth of water continuously over a flat, wide concrete slab. Aeration serves three purposes, the first and most important of which is the oxidation of iron salts so that they will precipitate, or drop out, in the settling tank. Second, aeration kills many forms of organic growths which cannot live in air. Third, it cools the water, making it easier to inject and retarding the corrosion rate.

Aerated water goes to a chlorination pit. Since it was almost impossible to obtain liquid chlorine for this purpose during the war, the Salt Water Company generated its own chlorine right out of the salt water. Carbon graphite electrodes wired to a low voltage, high amperage rectifier are immersed in the water to a depth of about 18 inches to allow for best diffusion. When the current is turned on, electrolysis begins; free chlorine, released from sodium chloride (common salt) molecules, bubbles up through the water. The deadly, greenish gas whose pungent odor may be detected around the chlorination pit kills or renders inoperable bacteria which reduce sulphates in the water to sulphides. If no chlorine were used, iron sulphide would soon choke and plug filter beds; deposits of the tenacious black sulphide may be seen on some aeration slabs before chlorine is administered.

Chlorinated water flows out into a settling pond, where baffles are so placed to keep water uniformly in motion throughout the pond until it can be pumped to the central treating plant.

At the treating plant, water is first given a thorough aeration, this time more nearly complete than at the collection center. As it falls through a cooling tower, water is broken up into tiny droplets which are cooled by evaporation. At least one cooling tower in the system is equipped with a large forced-draft fan which cools water from 20 to 30 degrees instead of the 5 degrees obtained by towers without fans.



When it leaves the cooling tower, water is ready for another and more nearly complete dose of chlorine. Now that liquid chlorine is again available, many treating plants in the East Texas system are discharging gas from cylinders of liquid chlorine into aerated water. Vaporizing through a regulator valve into a rubber hose, chlorine gas reaches the water through a porous diffusion thimble immersed in the treating pit. Bacteria which escaped chlorination at the collection center or which entered the water later usually succumb to this second application.

Immediately after it is chlorinated for the second time, water flows to the lime and alum (aluminum sulphate) mixing chambers; both chemicals are added to bring about flocculation, or gathering together of suspended solids in masses large enough to settle to the bottom. Alum has a slight acidifying effect on the water, but natural alkalinity is restored by the lime, so the two make a good team. Automatic chemical feeders drop alum and lime into the water at rates prescribed for proper flocculation.

Floc-laden water from the lime and alum chambers flows out into the first of a series of settling pits which are part of all treating plants. This pit, like others in the series, is made of a depression scooped and shaped in the earth, then covered with wire mesh over which 2½ inches of concrete are sprayed by the gunite method. Heavy, rust-colored floc particles may be clearly seen in the first section of the pit.

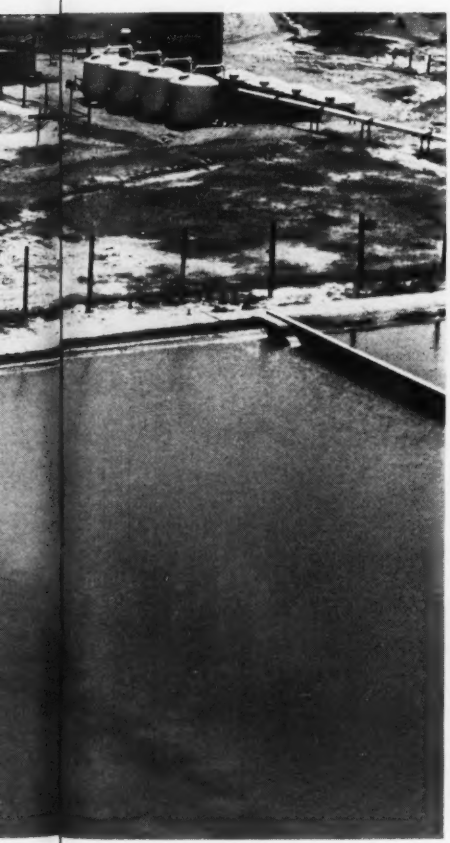
Moving on into other sections of the pits in the settling series through over-and-under baffles to eliminate "dead spot," the water becomes clearer and clearer. Floc is settling fast; water in the last section is almost completely clear—ready for the filters.

The East Texas Salt Water Disposal Company uses closed, pressure-sand filters. They are steel drums, rounded at top and bottom, about five feet high and from 72 to 96 inches in diameter. Inside these drums are layers of sand and gravel; fine sand at the top, progressively coarser gravel toward the bottom. Each filter handles about 5,000 barrels of water a day and must be cleaned, or backwashed, about every 24 hours. Filters in series can be manifolded together so that some may continue in operation while others are being backwashed.

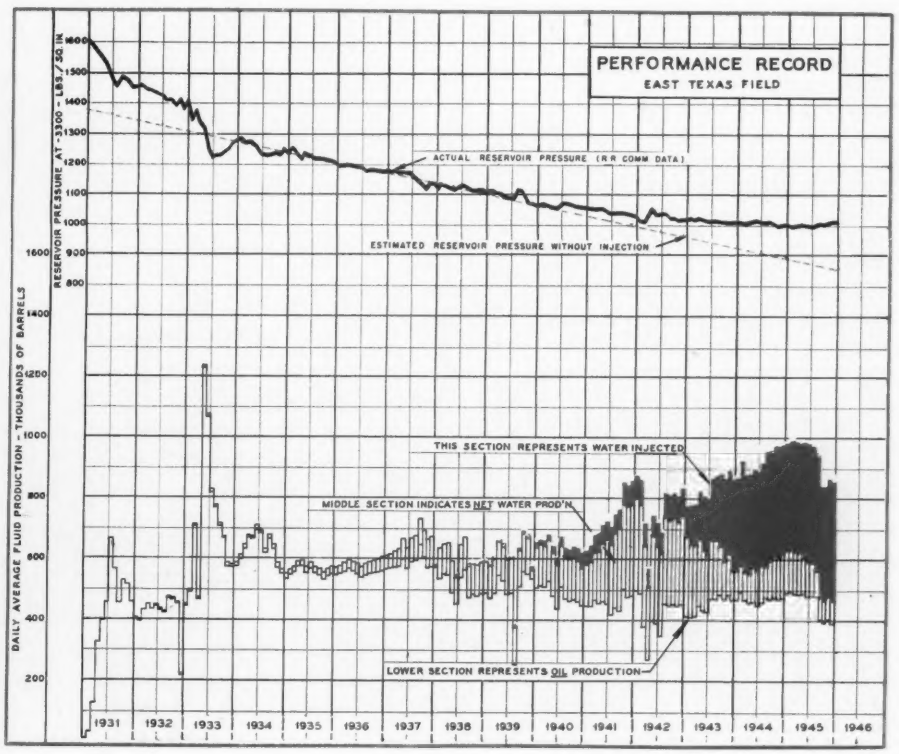
From filters to surge tank goes water so clear you can tell whether a dime is heads or tails at a depth of 15 feet. From the surge tank, filtered water flows continuously into the disposal well. Some wells take 10 to 14 thousand barrels a day under vacuum at the well head, but water must be pumped into other wells at high pressure, sometimes more than 300 pounds per square inch at the well head.

Continued injections will tend to deposit solids on the sand face at the bottom of the well. This sludge or filter cake will, in time, grow to such proportions that an occasional acidizing job is necessary. Hydrochloric acid is pumped down through a special string of small steel tubing inside the cement-lined or plastic-lined tubing to the filter cake, and the sludge is dissolved. By careful treatment and the use of proper chemicals, these clean-out and acidizing jobs have been kept at a minimum; in 1945, for instance, no wells had to be cleaned out, although more than 88 million barrels of water were injected.

Salt water is a highly corrosive chemical, and corrosion has caused considerable trouble in the disposal systems. This problem has been solved in some cases and minimized in others by the use of alloys and plastic coatings for such metal parts as pump impellers, tubing, and filters. Asbestos-



CENTRAL TREATING plant scene shows filters and surge tank in the background, aeration tower and settling pits in foreground. The dramatic significance of salt water injection is told in the accompanying chart.



cement pipe and cement-lined steel pipe for gathering and injection lines has cut corrosion in those departments to zero.

Have results obtained through subsurface injection of salt water been worth the time and money spent on the project? Yes, and that answer pleases everyone.

First, engineers of the Texas Railroad Commission, the Texas Game, Fish, and Oyster Commission, and the East Texas Anti-Pollution Committee declare that the field is now in better condition than at any time since its discovery. No salt water is allowed to spoil productive lands or pollute streams used for drinking or fishing purposes. Trees and green grass growing and thriving right up to the edge of the disposal systems provide dramatic proof that the end is worth the means.

Second, oil companies in the field have benefited by subsurface injections. The chart on page 11 shows that injection has already saved 136 pounds per square inch in reservoir pressure since the Salt Water Company began operations. More significant than that, there was actually an *increase* of 14.9 pounds per square inch in reservoir pressure last year, the first yearly increase since production began in 1930. During the first 39 months of Salt Water Company operations, there was a net decrease in field pressure of only 4.56 pounds per square inch.

Engineers familiar with reservoir behavior conservatively estimate that over 600 million additional barrels of oil will be recovered from the East Texas reservoir as a result of the pressure maintenance program. This 600 million barrels is over and above the amount that would have been recovered had the program not been inaugurated. In addition to these benefits, the maintenance of pressure has made it possible for many wells to continue flowing instead of lifting the oil to the surface by mechanical means. Just how much money has been saved in this manner is a matter for conjecture, but it is by any estimation considerable.

Initial costs, just as one might expect, were relatively high; it is a rule of thumb that new disposal systems cost about ten dollars per barrel of daily capacity. Thus, a 10,000 barrel per day disposal system costs about $100,000 for all facilities. Once the East Texas system got under way, operating cost-per-barrel dropped to about 1.4 cents. By comparison, a flat handling charge of 1.8 cents per barrel was set by the Salt Water Company, and this rate has remained unchanged.

Some water in the field, of course, continues to be handled independently by others. Humble Oil & Refining Company owns and operates three disposal wells for its own account, besides consigning large volumes of water to the Salt Water Company.

It is at Talco, some hundred miles north of the East Texas field, that Humble concentrates on its own disposal systems. Here, poured concrete pits are used, instead of the gunite-lined type. Smaller volumes of water are handled, but every barrel is subjected to thorough skimming, aeration, chemical treatment, settling, and filtration.

At Talco, forced aeration through submerged pipes has eliminated the need for chlorine and has greatly reduced the lime demand of the water, but during hot summer months a small amount of copper sulphate (bluestone) must be used to control algae, or scum-forming growths. Practically everything in Humble's Talco system works automatically. Let a level rise too high here, and an automatic switch starts a pump there. Chemical feeders are automatic, and chemicals are pre-mixed with water for more complete dispersal.

Yes, gone are the days when salt water was a matter to be considered lightly. The Humble Company, operating alone and jointly with others, has given the problem the attention it deserves. Result: Both Humble and the public are benefited. It has been a good solution for all concerned.

HUMBLE COMPANY'S TALCO SALT WATER DISPOSAL SYSTEMS SHOW RESULTS OF EMPHASIS ON GOOD HOUSEKEEPING

ALL THE LAVISH SPLENDOR OF A MEDIEVAL COURT ATTENDED THE CORONATION OF THE QUEEN OF THE FIESTA

Fiesta de San Jacinto

IN THE HEART of historic San Antonio, shaded from the hot Texas sun by the tall buildings which surround it, slumbers the Alamo. The Alamo knows equally the violence of war and the tranquility of peace. Within its walls more than 110 years ago Colonel William Barrett Travis and his small band of patriots gave their lives as payment for Texas' independence from Mexico. And here, for more than 50 years have been conducted the memorial services which open San Antonio's famed *Fiesta de San Jacinto.*

The first fiesta, held in 1891, was prompted by the announced visit to San Antonio of Benjamin Harrison, then president of the United States. As the date of his arrival coincided with San Jacinto Day, April 21, the citizens of San Antonio decided to celebrate both events with a flower carnival. The success of the first celebration assured its continuation and in 1896 the *Fiesta de San Jacinto,* as it is known now, came into being. One of the important attractions of the first and subsequent fiestas was a flower battle which took place in front of the Alamo. This colorful event was so distinctive and excited so much comment that *Fiesta de San Jacinto* is known to most Texans as the Battle of Flowers.

Actually the fiesta is a cooperative enterprise involving four large associations and numerous smaller ones. The

San Antonio's First Post-War Battle of Flowers Revives 55-Year Old Celebration of San Jacinto Day

Fiesta de San Jacinto Association acts in an administrative and coordinative capacity. The Battle of Flowers Association, oldest of the organizations, is in charge of a number of events, principally the Grand Parade. The Order of the Alamo, established in 1909, names the Queen of the Fiesta and is in charge of the magnificent ceremonies incident to her coronation. The Texas Cavaliers is the organization from which the King of the Fiesta is selected and the kingship, while being a position of extreme honor, is certainly no job for a man lacking either stamina or regal good humor.

With this background of historic significance and with the pent up enthusiasm of five war years when no fiestas were held, the carnival spirit of San Antonio overflowed as the fifty-first annual *Fiesta de San Jacinto* began.

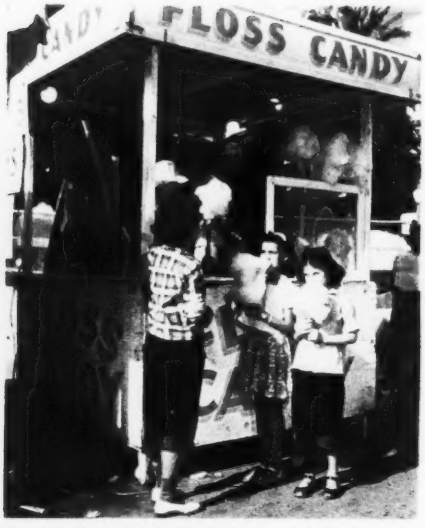
The traditional Pilgrimage to the Alamo opened the ceremonies at 6:00 P.M. on Monday, April 22. Soberly, reverently, representatives of some 200 military, civic, social, fraternal and school organizations paraded down Alamo

Battle Of Flowers

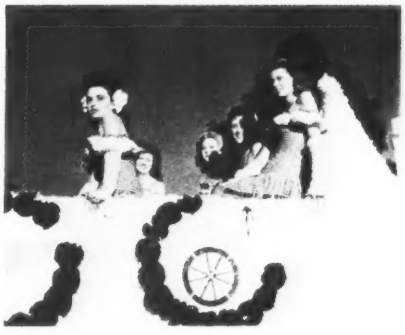
Fiesta de San Jacinto, celebrated in San Antonio about April 21, is known to most Texans as the Battle of Flowers, and the crowning event of the week-long celebration is the Battle of Flowers parade. Here in natural color are some of the scenes from this lavish spectacle.

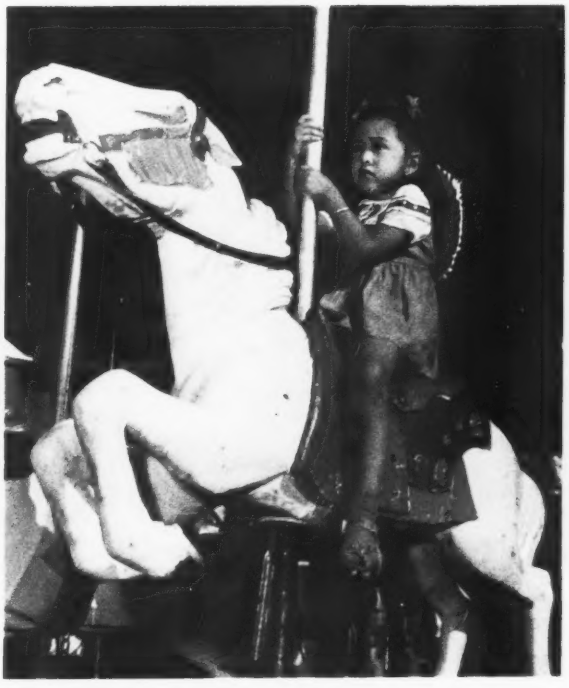
Left: Shaded from the bright Texas sun by gay umbrellas, military and political dignitaries awaited the arrival of the Queen and her court. Left, below: Color bearers led the parade through downtown San Antonio. Left, bottom: Prime attraction of the cavalcade section were these uniformed lady riders.

A birds-eye view of the parade as it passed the Alamo Cenotaph emphasized the geometrical precision of the banked rows of spectators.



Above and to the right are some of the decorative floats and lovely girls that contributed to the beauty of the Battle of Flowers parade. At the lower left is one of the flower-bedecked wagons in the cavalcade section of the parade. After the parade the younger set enjoyed the many attractions of the carnival as the floss candy purchasers and the carousel rider testify.





enotaph
ectators.

FROM HIS ROYAL BARGE KING ANTONIO XXIV GREETED THE SPECTATORS WHO THRONGED THE SAN ANTONIO RIVER BANKS

Plaza, laid their floral offerings in a huge colorful pile in front of the Alamo and then filed slowly through the historic structure.

After leaving the Alamo, the crowd gathered along the banks of the San Antonio River and prepared to welcome King Antonio XXIV. Delayed by a sudden shower which drenched both spectators and participants, the King's 100-boat flotilla, preceded by Indian guides, finally glided into view. A giant river monster captured by the Texas Cavaliers led the water-borne procession. Historical floats, barges filled with flowers, boats decorated to represent foreign lands, all preceded the King to the Arneson River Theatre where he stepped ashore to receive the keys of the city. In true royal fashion, King Antonio officially proclaimed fiesta week a period of merriment and revelry for all his loyal subjects. Then he proceeded to La Villita, the authentic Spanish village on the banks of the San Antonio River, where he held his first formal reception.

The next morning the King reviewed the 32nd Medical Battalion at Fort Sam Houston and then began visiting his subjects in their many fiesta week activities.

Tuesday night the children of San Antonio entertained. More than 1,000 boys and girls of various ages danced the "Ballet of the Lone Star" before an audience which filled the municipal auditorium. In seven parts, the ballet told the story of Texas from the very beginning of time; on through the Spanish, French and Mexican eras; into Texas' brief history as a republic, and then to its growth as a state. The children's pageant was one of the fiesta's highlights.

Wednesday's program included a trade parade featuring the floats of local industrial and business concerns. At 6:00 P.M., a River Carnival sponsored by the San Antonio Conservation Society depicted the various phases of Texas history and offered visitors authentic Texas fare and entertainment.

The program Thursday was extremely full, reflecting the rising tempo of fiesta activities. On Thursday afternoon, King Antonio reviewed a dress parade and acrobatic riding exhibition at Peacock Military Academy. At 6:30 P.M., the King presided at the annual band contest in Alamo Stadium where 30 high school organizations competed for music and marching honors.

All the splendor of the fiesta was focused Thursday night on the stage of Municipal Auditorium where the Order of the Alamo presented the Queen publicly for the first time. The coronation ceremonies, lavish almost beyond belief, brought together fiesta royalty from all parts of Texas. In a setting depicting a legendary Court of Honour, the duch-

esses with their maids and escorts were presented by the Lord High Chamberlain and took their appointed places. Last to enter was Her Gracious Majesty, Queen of the Court of Honour. She swept up the center aisle onto the stage and received from the Prime Minister the jeweled scepter and crown of the Order of the Alamo.

Early Friday morning, people began their mad scramble for vantage points from which to watch the crowning event of the fiesta, the Battle of Flowers Parade. Reserved seats erected at many places along the line of march had long since been sold. On building marquees, on roofs, on telephone poles and on even the Memorial Cenotaph in Alamo Plaza, people gathered. More than 500,000 lined the route of the parade, many waiting for hours under a broiling Texas sun.

Promptly at 3:30 P.M., the parade began its two-mile long march. Behind the Grand Marshal, who rode on horseback, came the command car in which were Governor Coke Stevenson, and Generals Jonathan Wainwright and Walter Krueger. They were followed by military units from Fort Sam Houston and other San Antonio military installations. Then came floats from various patriotic organizations followed by other floats entered by rural schools and San Antonio public schools. Thirty-five bands spaced at intervals in the procession kept the marchers stepping smartly, but the milling crowds jammed the streets so closely that progress of the parade was slow and painful.

The school floats were followed by a cavalcade section of beautiful horses and gaily costumed riders. Following them came other floats and then the Texas Cavaliers. Brilliantly uniformed in scarlet and blue, the Cavaliers served as mounted escorts to King Antonio whose carriage was pulled by two white and two Palomino horses.

As his carriage came abreast of the reviewing stand at Alamo Plaza, the King dismounted to join the military and civil dignitaries there and await the arrival of the Queen and her court. The progress of the royal party toward the Plaza could be gauged by the approaching boom of the crowd. Then there they were, each princess and duchess on a float that seemed even more beautiful than the one that preceded it. And finally came the Queen. The swelling roar of acclaim from thousands of parched throats was the thrilling climax to San Antonio's first post-war *Fiesta de San Jacinto*.

CLIMAX OF THE BATTLE OF FLOWERS PARADE WAS THE GLITTERING ROSE COVERED FLOAT OF THE FIESTA QUEEN

Products Line Progress

ENGINEERS KEEP a careful check as the line is laid in its underwater trench across the San Jacinto River, a few miles from Baytown. Big tractors churn around in Waxahachie Creek, south of Dallas, as they swing a length of coated line into position for final inspection.

Major portion of Coast-to-North Texas gasoline line completed

CONSTRUCTION is well under way on both sections of Humble Pipe Line Company's new 276-mile, 8-inch products line from Baytown to Dallas, an artery which will link one of the nation's largest refineries with the rich agricultural and industrial area of North Texas. Work is progressing on one section from Hearne to Dallas; the other from Baytown to Hearne. As of June 20, 91.7 miles of the line had been completed on the Hearne-Dallas section; 63.8 miles on the Baytown-Hearne section.

The route of the new pipe line follows the geometric axiom that a straight line is the shortest distance between two points. This, as veteran crews will verify, causes the course of true pipelining to run something less than smoothly. Rivers must be crossed; tunnels must be bored and casing placed under highways and railroad tracks; ditches must be dug in solid rock; often it becomes a struggle between man and the elements.

One of the most dramatically interesting phases of pipe line construction—and one which challenges all the ability and ingenuity of the crews—is the work of crossing a stream. At least two major rivers, the Trinity and the San Jacinto, have already been crossed, and countless creeks and bayous continue to dispute the forward progress of the line.

Spanning a river or even a creek calls for extra measures of skill and coordinated effort. Under competent foremanship and supervision, tractor operators display their prowess; ponderous machines go grumblingly about the task of snaking the line into place. If the stream is small, the great "cats" are taken right down into its bed, where they churn mud and water into a black froth as the pipe is held aloft and then lowered to its proper grade.

Once the crossing is made—and it can be done in a surprisingly short time—

the coating and wrapping machine resumes operations. The machine used on the Hearne-Dallas section of the products line offers something new in pipe line wrapping. It is, in effect, a double wrap, instead of the conventional single wrap, machine. In sequence, its continuous series of automatic operations is: a coat of molten enamel, a spiral wrap of gossamer Fiberglas, another coat of enamel, then a spiral wrap of asbestos felt. Prior to coating and wrapping, the line had been cleaned and coated with a primer to provide a bond between the steel and the enamel. It is anticipated that the Fiberglas wrap, by making possible the application of a thicker enamel coating and providing reinforcement for the coating, will increase protection against corrosion and reduce maintenance problems.

Pipe for the Baytown-Hearne section is being coated and wrapped by stationary machines in central plants before it is sent to the field.

A mile or so in front of the coating and wrapping machine go welders and a pressure test crew. After segments of line are welded, scrapers are put through by compressed air. Then the section is closed, air pressure of 100 pounds per square inch is built up in the line, and welds are tested for leaks. These air pressure tests are made at intervals not to exceed 2½ miles. As sections of the line are completed, beginning at Baytown and proceeding north, segments between block valves will be filled with gasoline and subjected to a 1500 pounds per square inch hydrostatic pressure test.

TIME OUT for lunch, and a short rest period for men and machines in a North Texas wheat field.

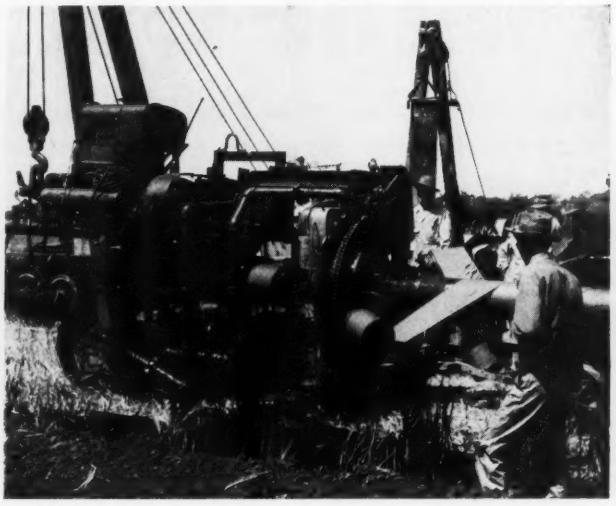
Complete cathodic protection will be given the products line to guard against corrosion at points where the protective coating may be or may become faulty. Electrical connections are being provided at half-mile intervals for testing and application of this protection.

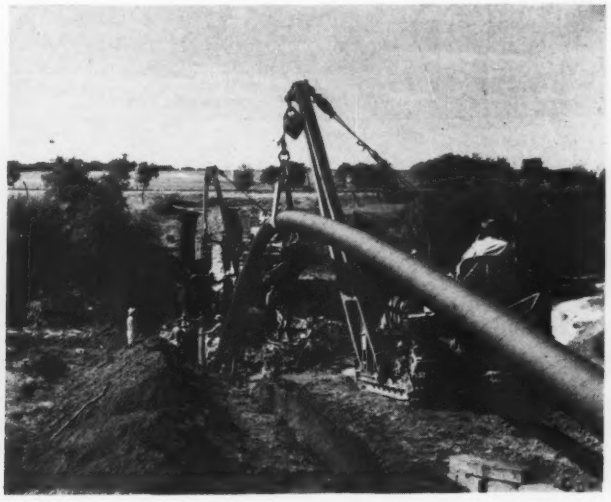
The new line follows Humble Pipe Line Company's butane-propane line from Baytown to Satsuma Station northwest of Houston; from there it goes straight to Navasota and Hearne. From Hearne it follows new right-of-way to a terminal north of Waco, from which point it proceeds northward to Dallas.

The Sales Department will operate terminals and storage facilities near Houston, Hearne, Waco, and Dallas.

Built of all new steel pipe, the line will cost about $4,000,000. As now planned, it will have a delivery rate of about 15,000 barrels a day of gasoline and other products.

AUTOMATIC DOUBLE WRAP MACHINE WINDS ON TWO LAYERS OF PROTECTIVE COVERING . . . MAKES SMOOTH, FINISHED JOB





CREEK BANKS AND BEDS AFFORD SURFACE GEOLOGISTS EXCELLENT OPPORTUNITIES TO STUDY SURFACE FORMATIONS

The SEARCH for OIL

By Olin G. Bell, *Production Geologist, Gulf Coast Division*

The first in a series of articles to explain how through geology and its younger associated sciences man finds oil sands deep in the earth.

Aristotle once said, "He who sees things grow from the beginning will have the best view of them." Before entering, then, upon a discussion of geology, its beginning and history, and its place in the oil industry, it might be well to begin with a clear definition of the science.

Geology is a study of the earth, its origin, development, form, structure, and physical characteristics, and the occurrence and development of organisms.

While that is a rather long and comprehensive definition, it truly covers the whole of the science. It might also be added that geology is a natural science and as such uses chemistry, physics, zoology, botany, astronomy, and other sciences very intimately. Actually there is no sharp line of demarcation between the various sciences, and, therefore, each one merges imperceptibly into the other. Geology is no exception; so we have geo-physics, geo-chemistry, and other geo-sciences, which deal with those border zones between geology, as such, and other related sciences, and their practical applications.

The earliest record we have in geologic literature is of observations by the early Greek philosophers prior to 600 B.C. Next, we find some of the early scientists during the period from 600 B.C. to about 1800 A.D. writing on some of their

observations which were really and truly geologic in nature. These men were primarily teachers, preachers, physicians, philosophers, chemists, each of whom devoted a part of his spare time and thought to the study of geology. It was not an organized science at that time, but many of these men while engaged in their various professions became interested in the interpretation of geologic observations and discussed them in their writings. It is doubtful if they knew they were really writing geologic literature.

The first American work was in 1787 by Johan David Scoph, a surgeon in the Hessian Army; a later development came in the period from 1800-1910. Some of our early scientists, such as Benjamin Franklin and Thomas Jefferson, devoted a part of their time to the study of geology, and the first university work in geology was done by Benjamin Silliman, first professor of geology at Yale University in 1802.

The period of public geologic surveys began in 1830, although North Carolina started a state geologic survey as early as 1824. The next was Massachusetts in 1830. Tennessee in 1831, and others followed in rapid succession. Even Texas was not far behind and had its first state geologist, B. F. Shumard, in 1858. These, however, were little more than exploring expeditions. Stimulated by these first efforts in the states, the U. S. Government, in 1834, recognized the need for systematic geologic exploration and assigned a geologist to an expedition sent out to survey the region between the Missouri and Red (in Canada) Rivers.

Next followed the period for railroad surveys from 1850-1890. During this era of westward expansion of our civilization, geologists were employed by the railroads to study the natural resources along their proposed routes, principally the present main transcontinental rail routes from the Mississippi Valley to the Pacific Coast.

The United States Geological Survey was established in 1870 and its earliest work was largely in connection with the westward movement of our population across the Plains States to the Mountain States and then on to the West Coast. While this geologic activity was growing, the application of the science to petroleum prospecting was yet to come.

The first oil well was drilled in Pennsylvania by Drake in 1859. From this the oil industry developed slowly and spread to other states. No relationship of geologic conditions to oil occurrence was recognized at that time. Thirty years later, however, Dr. I. C. White, then professor of geology at the University of West Virginia and state geologist, observed that the oil and gas fields of Pennsylvania and West Virginia all were located on "anticlines" or arches formed by the upfolding or bending of the rock strata. He thereupon expounded the "anticlinal theory" for the occurrences of oil and gas, although it had been suggested by a Canadian geologist, William E. Logan, as early as 1843. This theory was not readily accepted by the oil industry, but gradually it was seen that it was meritorious and explained the geologic occurrence of oil and gas in those areas.

Thus originated the function of the geologist in the oil industry and also the title, petroleum geologist, which members of the profession bear. It was not until about 1900, however, that geologists were used to any appreciable extent in the industry. From that time until approximately 1920 they were used primarily to look for anticlines and their work consisted principally of exploring and mapping the surface exposures and distribution of the geologic formations. They were frequently known then as "rockhounds."

By 1920 the more easily found anticlines had been located and mapped, and the problem of finding new ones became

OUTCROPS OR EXPOSURES found in highway and railroad cuts are studied for composition, color, hardness, and texture, as well as for fossils.

more complicated. As a result, the geologist began to expand his *modus operandi* and improve his technique. It was necessary to find hidden "structures," or anticlines, not observable by outcrop studies, because they were concealed under a heavy layer of soil, or alluvial materials, or deposits of glacial drift. In some cases, anticlines existed at some depth below the surface yet the strata at the surface would give no indication of their presence.

By this time it was noted that oil also occurred under conditions other than in the simple anticline. An oil reservoir could be the result of other geologic conditions, which were, in effect, a modification of the anticlinal principle. Oil was then known to occur on or around salt domes, in sand lenses, under conditions of faulting, where the structural position of two or more strata did not conform to each other in the normal or orthodox manner.

This widened the range of geologic interpretation and intensified the need for geologic work which in turn started a trend of specialization among petroleum geologists. The need for paleontologists, particularly those qualified in micro-paleontology, became greater. The need arose for intensive subsurface correlation and interpretation. This, in effect, separated the work of the surface geologist from that of the subsurface man. The use of geophysical methods was proven successful for finding hidden or deeply buried salt domes, thus necessitating the specialization of geologists in this type of exploration. Increased drilling throughout the industry, especially under more or less obscure geologic conditions, required the use of scouts to watch the operations and development work of other companies, and to obtain information, such as well cuttings, cores, and logs to guide the employer company in its activities.

Later, in the period from 1930 to 1935, the need arose for geologists to devote full time and attention to the drilling, logging, coring, testing, and completion of wells, particularly wildcats. Thus developed another specialization, that of the production, or exploitation geologist.

The geologist is not only concerned with the finding of oil and gas but is also intensely interested in the behavior and performance of the reservoir during its productive history. He is, therefore, interested in the study of reservoir conditions and the most efficient methods of producing the oil and gas.

This tendency toward specialization made necessary and laid the groundwork for sub-departmentalization within the field of geology. Most companies use a slight modification of the general plan but almost always this includes such subdepartments or sections as: land and leases, titles, scouting, surface mapping, and core drilling, subsurface, paleontological, geophysical, and exploitation (or production geology). Of course, some of these sections do not treat directly of geology but are so intimately related to geologic work that they are closely integrated with the function and operation of a geologic department.

The prime function of a geologic department in any company is the exploration for and exploitation of oil and gas in the most efficient manner. Of necessity some of its subdivisions are engaged in the direct objective, others in functions ancillary to the principal one. The interrelationship of these branches and their relationship to other departments of the whole company should always be clearly understood.

There is, and must be, an administrative head of the department, usually designated as the chief geologist, or, in the case of the Humble Company, a vice president and member of the Board of Directors who is manager of the Exploration department. His work is that of upper level management and administration of the department and coordination between its branches and other departments of the company and other companies. Under his direction the chief geologist supervises the Geophysical, Exploration, and Research division and the Geologic, Lease and Scouting division, both of which have a number of sub-divisions.

Geologic exploration and exploitation go hand in hand with drilling for and producing oil and gas. In order to decentralize the work of the Geologic, Lease and Scouting division, the department is further subdivided into territorial divisions to conform to the Production department divisions, thus providing close cooperation and coordination between the Geologic and Production departments throughout the Company's operating territory.

Each division is headed by a division geologist who has a section staff similar to that under the Geologic, Lease and Scouting (functional) division in Houston. In this way, Humble carries the practice of decentralization down to the lower levels of operation and places as much responsibility as possible on the individual employees in the outlying districts. Close cooperation is maintained with the personnel of the Production department as well as with the chief geologist.

One of the prime functions out in the divisions is that of surface geology. The surface geologists are those who study the surface exposures and outcrops of formations and their

ANGLE OF DIP of formations is carefully checked by the surface geologist with Brunton compass, standard equipment for all "rockhounds."

ELECTRIC LOGS HELP THE GEOLOGIST LOCATE STRUCTURES FAVORABLE FOR THE ACCUMULATION OF OIL AND GAS

distribution over the areas in which the company is interested. This study is on a regional basis and oftentimes includes several states. These geologists map the aerial geology with particular attention to probable structures; they are the modern version of the earlier "rockhounds" who went about searching the Mid-Continent and Appalachian regions for anticlines. They explore and examine all the surface exposures that can be found; note the type of rock, whether shale, sandstone, limestone or any variation of these; the composition, texture, color, hardness; and the type of soil resulting from the weathering of the rock. The form of topography resulting from the weathering and erosion of the formation is frequently characteristic and important in recognizing the distribution of the beds.

These geologists also note whether or not fossils occur in the formations, and, if so, they make a systematic collection of them in well selected localities. This is helpful in identifying these same beds in other areas where they are found.

Much of the surface area of the United States has been mapped by surface methods for many years, and all the work which has previously been done is still available and is utilized by these men in their surface studies. This does not mean, however, that the work is complete and has reached its final form. Actually, surface work is undergoing constant revision as new knowledge of the formations, fossils contained in them, physical characteristics, extent and distribution, and other information pertaining to them comes to light. Also many of the formations are now frequently subdivided into smaller groups or members, and these in turn are remapped in greater detail.

There is still much surface work to be done in Texas, even into the coastal areas which are frequently covered by heavy soil and vegetation, and in some cases even by swamps and tidal areas.

The work of the surface geologist is oftentimes aided by core drilling. There are many areas where the surface formations are concealed by deep soil, windblown sands, river silt, alluvial material, gravel, glacial drift and even heavy vegetation. In such cases the surface geologist is unable to study accurately the structural position and extent of the formation immediately underlying these covering materials. In such areas a light portable drilling rig is sometimes used to penetrate the formations below this surface mantle and bring samples of the strata in the form of cores or well cuttings to the surface for examination and study.

Most outcrops or exposures are found in gullies, creek banks, road or railroad cuts, cliffs or rugged hills, all of which afford the geologist an excellent opportunity to study them. In some cases he watches for hand dug wells or cisterns and other excavations for fresh formation exposures. Where he is unable to find natural exposures he may even have pits or trenches dug down beneath the surface soil in order to find the formations lying just beneath.

The work of the surface geologist is never completed.

The subsurface section of a Geologic department secures information from several sources, but principally that derived from well logs, cuttings, paleontological reports, geophysical surveys, and electrical logs. These data are carefully studied and utilized to construct the subsurface position and distribution of the formations in that area. It is from knowledge of this nature that the geologist is able to determine the location of areas or structures favorable for the accumulation of oil and gas.

This work is essential in exploration work and the selection

of lease blocks, locations for wildcat or exploratory wells, and, when several wells are drilled, to determine, during the progress of drilling, the structural position of each well and to predict the probable depth at which formations occur which are known to be productive in other areas. Also in the development, or exploitation, of a proven field a subsurface geologist uses the same methods but has much better and more dependable information because of the fact that wells are drilled closer together and the sources of information are more localized. This work is very helpful in determining the position of faults or other breaks in the continuity of the beds and in the distribution of formations.

The geologist uses information obtained from wells drilled by other companies as well as from his own, as this gives him the maximum data obtainable. The greater the amount of information available the more detailed and accurate are his maps and conclusions.

Numerous and varied subsurface studies are conducted. Among these the subsurface geologist constructs subsurface contour, or "structural" maps, using the same principles as are used in the preparation of topographic maps. The principal difference is that in the subsurface map the contour line, or line passing through all points of the same elevation, is constructed on top of some formation or zone, below the surface. Such maps show the structural configuration of the key bed used as if it were stripped of all overlying formations.

By constructing, comparing, and studying these subsurface structural maps the geologist is able to recognize and recommend trends which have possibilities of being productive. He is also able to indicate possible productive extensions in known fields. This information is very critical and useful in selecting drilling sites and in preparing the drilling program both for exploration and also in the development of a field.

Isopach maps are also prepared for the more important formations or sand members occurring in the area. These are maps showing the thickness of the unit being mapped and its variation in thickness from place to place. Such maps are particularly useful in depicting subsurface conditions, in locating structural basins, and in estimating reserves of oil and gas in the reservoirs.

The specialized functions of the several sub-divisions which comprise the geologic department as such, and the details of how these functions are interrelated and coordinated into a balanced and comprehensive program of searching for oil will be carried in future articles in this series. Subjects to be discussed will include paleontology, geophysics, scouting, land and lease activities, and production geology.

SELECTION OF LEASE BLOCKS AND LOCATIONS FOR WILDCAT WELLS ARE MADE ON THE BASIS OF GEOLOGIC FINDINGS

LAND RIG DRILLS FOURTH WELL ON AN ARTIFICIAL ISLAND ABOVE FLOOD LEVEL IN BAYOU DES GLAISE FIELD

Drilled from ISLANDS

MAN'S INGENUITY has been his salvation in the seemingly hopeless battle he has waged against the elements. Faced with destruction and ruin by drought and flood, he has erected dikes, levees, and dams and has dug drainage ditches and irrigation canals to rescue soil, and himself, from too little or too much water. The human race being constantly thwarted by nature and obstructed in its attempts to gain desired ends is exemplified by Humble drilling and production experts in countless battles with the elements.

One such clash occurred when Humble was wildcatting in the swampy lands of lower Iberville Parish, Louisiana. There, between 28-feet high levees marking the east and west boundaries of the Atchafalaya River Basin where the earth catches only fleeting glimpses of sunlight refracted through from five to 24 feet of drainage water, is located the unique Bayou des Glaise oil field.

To bring the field to its present state, Humble men waged a winning fight against the mud and muck that oozes over the lowlands of the Atchafalaya River Basin, against the sudden and destructive high waters of frequent floods, and against the high cost of drilling for oil under such conditions.

The first problem to present itself to those searching for oil in that area was a means of transporting heavy drilling equipment to the test site. It had been solved previously when Humble men found oil in other isolated delta regions of Louisiana after digging canals and moving machinery to the location on barges. Work was begun on the needed waterway.

Next came the important matter of securing a firm foundation for the rig and other equipment necessary to drilling operations. This, too, was answered in precedent. Humble had drilled from platforms on piling to secure oil in Galveston Bay, at Goose Creek, and in other fields. Piling was driven, platform constructed, barges loaded with gear and towed in, machinery set in place, and drilling commenced. Operations were normal as the bit ate its way several thousand feet into the earth beneath the swamp water. The wildcat's location was its only unusual feature.

Then disaster struck! Swollen waters of the giant Mississippi River poured over its levees, surged into the channel of the Atchafalaya River, boiled out of its banks, and completely inundated the area of the Atchafalaya Basin. Work

GIANT DREDGE with 250-foot crane and 12-cubic-yard bucket digs canals and builds islands. Below is a typical island on which a crew is rigging up. High canal bank in the background is built with dredge spoil, and is designed to help protect the island from flood water.

stopped. Men were rushed from the well's location to the safety of high ground to wait for the flood waters to recede.

Returning Humble crew men found water had covered piling, platform, and part of the equipment, leaving in its wake thick deposits of silt and sediment. The canal was re-dredged, machinery and platform cleaned, and drilling resumed only to be halted again and again by rapidly rising flood waters.

Persevering Humble engineers redoubled their efforts, locating drilling equipment for new tests on piling with platforms higher than the first. But with each new effort, high water returned to stop drilling. The wildcats drilled under such conditions were hampered and harassed by the elements and doomed to failure.

There must be some way to get at the oil, reasoned the operators in the Bayou des Glaise field and Houston office engineers, as they sought another approach to the problem.

Fifteen years earlier, drillers on the west coast secured production from under the ocean by directionally drilling wells from locations ashore—on solid ground. Bayou des Glaise offered no

solid ground but why not put some where none existed? Why not, engineers reasoned?

The canals were reworked when the water subsided and the soil removed was used to construct an earthen island barely large enough for derrick, boilers, and pipe racks but high enough to be out of the water during floods. Mud pumps, tanks, electrical transformers and motors, mud supply and tool house were located on barges tied up at the island dock. The first test on a man-made island was brought in as the discovery well on May 27, 1944. Production was secured but the expense of dredging a canal and constructing an island for one oil well made the acquisition cost out of proportion to potential return.

For a number of years the water heights in the Atchafalaya Basin had shown a tendency to a gradual annual increase. In eight years its low at the Morganza Spillway rose from under three feet to more than five while its high increased from about 21 to more than 31 feet. The field's location, 35 miles downstream where the basin widens considerably, afforded some protection for Bayou des Glaise but waters there indicated the same trend, fluctuating between two and 23 feet. Engineers were still fighting the high waters.

Both difficulties were overcome by a single bit of strategy. Subsequent islands were raised to a minimum of 24 feet and were lengthened to permit four, then five, and, in the near future, six wells to be fanned out to proper bottom hole spacing from a highly concentrated area by directional drilling. The first well, under the new program, was drilled at the extreme end of the island away from the canal and following wells were drilled by skidding the rig only 30 feet toward the docks to each new location. Six wells will occupy an area of 30 x 180 feet of an island 370 x 260 feet with the surface 30 feet above the mean land level in the Bayou.

The new plan was successful, conquering the flood waters and reducing the unit acquisition cost to a more reasonable figure. Too, the concentration of wells also assured minimum operational expense by making possible grouping at one location of oil gathering system, tanks, and well servicing facilities for six wells instead of one.

More islands with clusters of Christmas trees and tanks will rise in the future, here and in other swampland oil fields—silent monuments to the ingenuity of Humble men and their victory over the elements at Bayou des Glaise.

PRODUCTION TANKS are concentrated in groups and are raised above flood level. Below, engineer checks producing well No. 3 in the shadows of the rig drilling on well No. 4. The first two producers on the same island at Bayou des Glaise are to the engineer's left.

By the way . .

TWO HUMBLE employees were elected to high positions at the annual meeting of the American Association of Petroleum Geologists at Chicago early in April. D. PERRY OLCOTT, head of the Statistics and Evaluation section of the Geologic, Leasing and Scouting department, was named vice-president of the A.A.P.G.; F. W. ROLSHAUSEN, chief paleontologist for the Company, was elected president of the Society of Economic Paleontologists and Mineralogists.

Recognition for War Service

Twelve employees and former employees recently received the Naval Ordnance Development Award lapel emblem, awarded by the Chief of the Bureau of Ordnance of the United States Navy for "the part (they) played in research and development work conducted by this University." This award came from D. LUKE HOPKINS of the John Hopkins Applied Physics Laboratory to: M. A. ARTHUR, J. C. JACOBS, J. A. NEWSOME, JR., T. W. LYTLE, J. N. TULLOS, DICK MANEVAL, LEO BROUSSARD, J. M. LOHSE, DR. L. G. HOWELL, F. W. HUDSON, C. C. BIES, and JOHN BUSACKER.

Two of the group were singled out for additional recognition by the Navy. To M. A. ARTHUR and J. N. TULLOS, REAR ADMIRAL G. F. HUSSEY, JR., Chief of the Bureau of Ordnance, also sent Certificates of Exceptional Service to Naval Ordnance Development. "The congratulations of the Bureau of Ordnance are extended to you for your outstanding performance in connection with the research and development of the proximity fuse," ADMIRAL HUSSEY said in his letter to the two Humble employees.

Retirements

HENRY A. STRICKLAND, 63, commission sales agent at Abilene, retired on October 1, 1945 . . . MRS. NORA PRUITT SVAHN, 55, Houston Office Building Maintenance, on March 23 . . . MRS. HAZEL GEORGE SETTLEMYRE, 55, Purchasing department, Houston, on April 5 . . . MILLARD M. NASH, 49, gate valve repairman, Longview Station HPL, on March 5 . . . OTTO RAMIN, 55, carpenter at Baytown Refinery, on April 8 . . . THOMAS C. WILSON, 63, Pierce Junction HPL, on April 1 . . . MARK C. FOLEY, 65, Longview District Superintendent, HPL, on April 18 . . . FRANCIS M. SLOAN, 65, assistant foreman, coordination department, Baytown refinery, on April 15 . . . DANIEL W. WOFFORD, 61, Production department District Superintendent at Roanoke, Louisiana, on April 22 . . . ALEX JOHNSON, 53, laborer at Baytown Refinery, on May 25 . . . and GROVER C. TABET, 61, Compound Supervisor at Baytown Refinery, on May 27.

Deaths

ROY W. SANDERS, SR., 59, engineer at HPL Baytown Station, died on March 23 . . . CHARLES BYNUM, 43, relief driller and fireman at Stratton Production, on March 25 . . . EDWARD L. ROBINSON, 28, helper at Baytown Refinery, on March 26 . . . HASKELL COOKE, 42, assistant shift engineer at Baytown Refinery, on March 30 . . . CAGER H. CARNES, 37, engineer at Katy Gas Plant, on March 31 . . . WILLIAM P. MCCAWLEY, JR., 31, Pumping & Gauging department, Baytown Refinery, on April 10 . . . BRYAN STRAVOSKI, 37, relief driller and fireman at Maurbro Production, on April 23 . . . REYNOLDS H. BLUNT, 33, chemist at Katy Gas Plant, on April 26 . . . HENRY L. SKEETE, 41, gang pusher at Baytown Refinery, on April 26 . . . NATT H. HALL, 62, employment manager at Baytown Refinery, on May 1 . . . JOHN P. RANKIN, 43, Tomball Natural Gas System, on May 3 . . . and FRANKLIN THOMPSON, 54, compressor man at Baytown Refinery, on May 10.

Employees who died while in service and whose deaths are reported after Army records have been completed: DUDLEY R. IVES, 30, rigger at Ingleside Refinery, reported missing since April 16, 1944, killed in action in the Southwest Pacific . . . JIMMIE R. BARBER, 30, draftsman in the East Texas Division office, missing since August 5, 1944, killed in action in the Southwest Pacific . . . and JOEL N. WHITTEN, 27, laboratory helper in Geophysics research, Houston, missing since August 30, 1944, killed in action.

Annuitants who have died in recent weeks are: ROBERT J. GRIFFIN, 66, formerly farm boss at Chalk Production, retired since July 7, 1944, died on April 16 . . . THOMAS R. HANRAHAN, 65, formerly superintendent of the Southern Division of Humble Pipe Line Company, retired since July 3, 1945, died on April 24 . . . and JESSE A. GLOVER, 68, pipe liner at Kemper Station of Humble Pipe Line Company, retired since July 1, 1942, died on May 21.

The HUMBLE WAY

VOLUME II MAY-JUNE NUMBER 1

Facts Behind the Figures 1
The Road, the Auto, and Oil 4
Back to the Sand 8
Fiesta de San Jacinto 13
Destination Dallas 18
The Search for Oil 20
Drilled from Islands 25
By the Way 28

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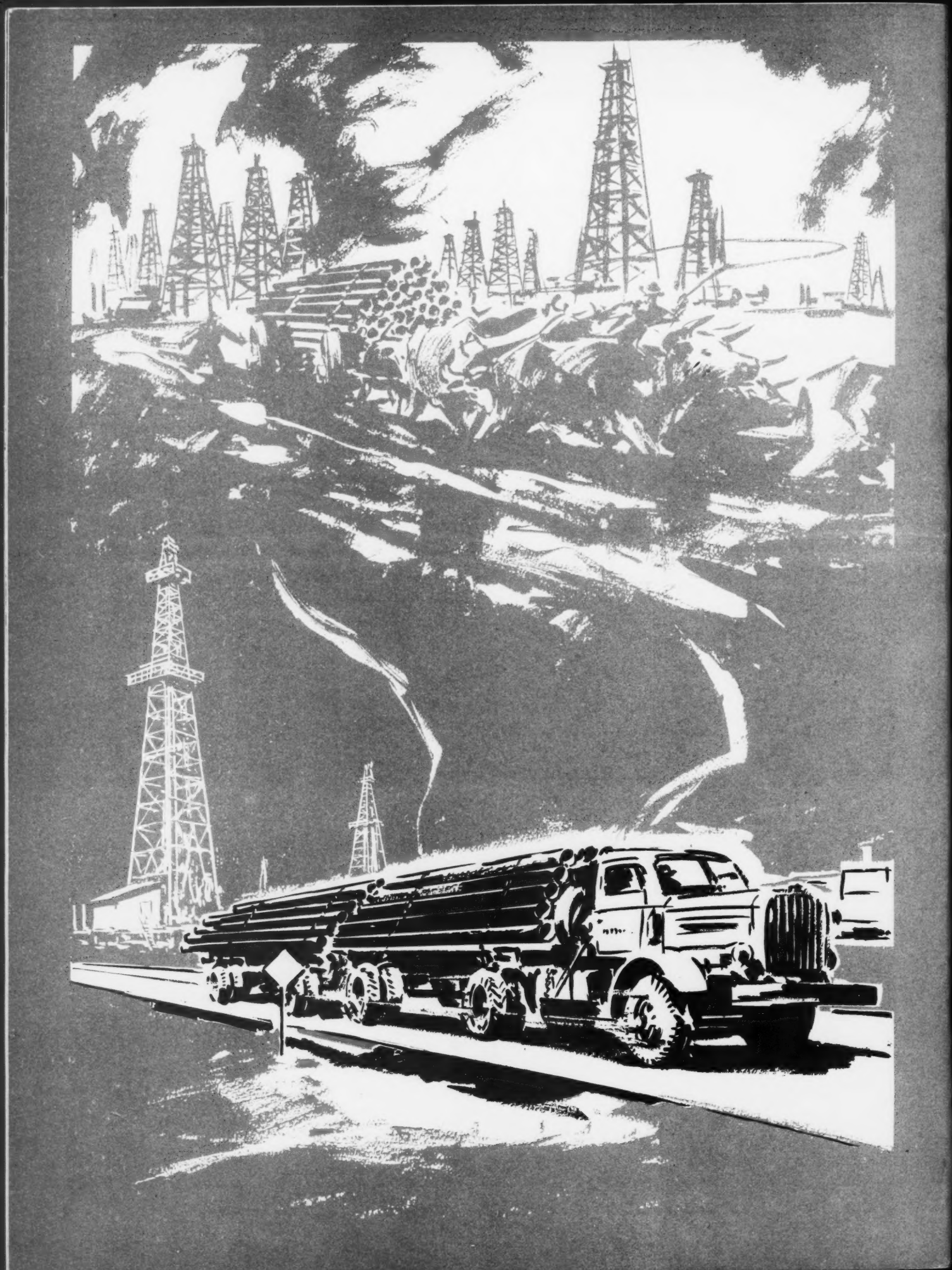
COOL, INVITING SPOTS are routine with the surface geologist who sees them every day as he walks creeks in search of telltale outcroppings.

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